

Reproductive biology of *Arvicola sapidus* (Rodentia, Arvicolidae) in the Ebro delta (Spain)

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Abstract

Studied the reproductive cycle of the southwestern water vole, *Arvicola sapidus* in the Ebro delta (Tarragona, Spain). 145 specimens (79 ♂♂, 66 ♀♀) captured between 1981 and 1984 were analysed. To evaluate the maturity and sexual activity in males the cytological analysis of the testicular content, minor and major diameter of the testicle and length of the seminal vasicle were considered. In the females, the state of the vulva, development and vascularisation of uterus and ovaries, and embryos and placental scars were registered.

The presence of spermatozooids is constant in adult individuals throughout the year. The seminal vesicles and the testicles vary considerably in size throughout the year. The minimum is reached in December and January, and the maximum in June. Between March and October all adult females are sexually active. The sexual activity is lowest in December–January with values around 35–45 %. The presence of pregnant females is limited to the February–October period. The average litter size is 3.31 ± 1.20 , $n=19$. The continued sexual activity of some females during autumn and winter, the constant presence of spermatozooids in males throughout the whole year as well as the capture of juvenile individuals in January, suggest the possibility of reproductive activity in November and December. Extrinsic factors may regulate to a certain degree the increase or decrease of sexual activity in different years.

Introduction

There is little information so far on the different aspects of the bionomic status of *Arvicola sapidus*. This species inhabits all of the Iberian Peninsula and southern, central and the north west tip of France (MILLER 1912; HEIM DE BALSAC and GUISLAIN 1955).

The information concerning the characteristics of the biological cycle of this rodent in all of its area of distribution is very scarce. Apart from the results obtained by DELOST (1968) about the reproductive characteristics of a population near the Tarn river (France) during one whole annual cycle, the rest of studies are less detailed. Such studies deal with descriptions on the sexual state of specimens obtained during non periodical catches (GOSÁLBEZ 1976; ZABALA 1983) or those dealing with references included within general treatises on mammals or rodents (DIDIER and RODE 1935, 1939; SAINT-GIRONS 1973; LE LOUARN and SAINT-GIRONS 1977; REICHSTEIN 1982; BAUDOIN 1984).

The purpose of this paper is to determine the reproductive characteristics and particularities of *Arvicola sapidus* in north east Iberia. This study, the first one concerning the subject in the Iberian Peninsula, was carried out in the Ebro delta (Tarragona).

Material and methods

The specimens analysed have been trapped each month from January 1983 to December 1984, at the banks of the canal network surrounding the Encanyissada lagoon in the Ebro delta (Tarragona, Spain). In addition, specimens were collected in the same area in January 1980, March, April and December 1981, and between January and March 1982. In all, 79 males and 66 females were studied.

From each specimen the body weight was taken, as well as the following measurements: head and body length, length of tail, hind foot length and ear length.

In order to determine the stage of maturity and sexual activity in males, the following characteristics and parameters were considered: position of testicles (abdominal or scrotal), testicular cell content (GOSÁLBEZ et al. 1979), minor and major diameters of the testicle and length of the seminal vesicle (GOSÁLBEZ and SANS-COMA 1976).

In the testicular squashes the following categories were distinguished:

immature: specimens lacking spermatozooids and spermatids in the testicle.

submature: specimens with few spermatozooids and spermatids in the testicle.

mature: specimens with complete reproductive capacity determined by a large amount of spermatozooids in the testicle.

In the females, the characteristics under consideration were: status of the vulva (open or closed), presence of mammary tissue, stage of development and irrigation of uterus and ovaries, and presence and number of embryos and placental scars.

The categories established are:

immature: specimens with closed vulva, whose uterus and ovaries are not much developed nor vascularised and lack placental scars.

Submature: specimens with open or closed vulva and whose uterus and ovaries are slightly developed and never show placental scars.

Inactive mature: specimens with closed vulva and uterus and ovaries developed, though scarcely vascularised. Placental scars may be present.

Active mature: specimens with open vulva and with completely developed and vascularised uterus and ovaries. There may be placental scars.

Results

Reproduction in males

Fig. 1 reveals that all individuals weighing less than 150 g are immature. Individuals between 150 and 176 g are at different stages of maturity, while all specimens weighing more than 176 g are sexually mature.

Some specimens captured in November are adults accounting to their size but their testicular squashes reveal a very small number of spermatozooids. The testicular lengths of these individuals ranged between 7.0 and 8.9 mm and the lengths of the seminal vesicles were 5.0–9.5 mm (fig. 2). The length at which the individuals show reproductive capacity at the population level are 12.5 mm for the testicle and 9 mm for the vesicle. That is, even though these specimens have reached adult dimensions morphologically and metrically, the small size of both organs suggests that the spermatogenesis has been altered, possibly due to an attenuation in the rhythm of gonad development because of environmental changes. If this were the case, those individuals born in the second half of summer would reach maturity later than those born in the spring, given the same bodily development.

Even though the adult specimens always present spermatozooids in the testicle, this organ and the seminal vesicle undergo important changes in size throughout the year (fig. 3). In December–January both parameters reach minimum values in the adults. In February, a progressive size increase commences, reaching the maximum in June. From this month on a decrease in size of both organs can be discerned.

The product of the two testicular diameters and the length of the seminal vesicle during the February–October period are clearly correlated (fig. 4). Below 65 mm² for the testicular diameter product and 5.5 mm of seminal vesicle length only immature individuals appear. Submature individuals are limited to the 65–105 mm² range of testicular diameter product and 6.0–8.0 mm range for the length of the vesicle. Above upper limits all the specimens can be considered mature.

Reproduction in females

From March to October, 100 % of the mature females studied were sexually active (fig. 5). In November, this percentage decreased notably and the minimum values, around 35–45 %, were reached in December and January.

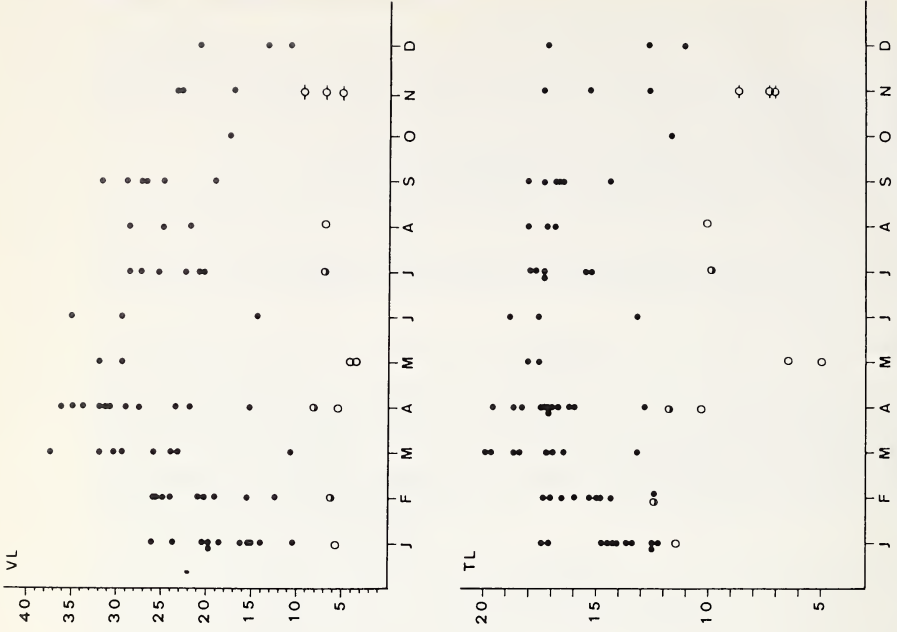


Fig. 2. *Arvicola sapidus* from the Ebro delta. Relationship between the sexual status of males and the length of the seminal vesicle (VL, in mm), and the length of the testicle (TL, in mm). (○): immature specimens; (◐): adult-size specimens; (●): mature specimens with few spermatozooids; (◑): mature specimens

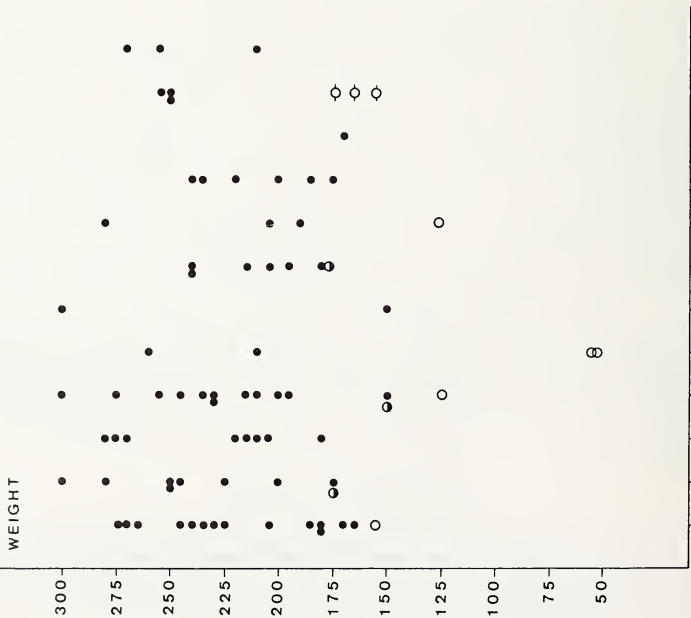


Fig. 1. *Arvicola sapidus* from the Ebro delta. Relationship between body weight (in g) and sexual status of males throughout the year. (○): immature specimens; (◐): adult-size specimens; (●): mature specimens with few spermatozooids; (◑): mature specimens

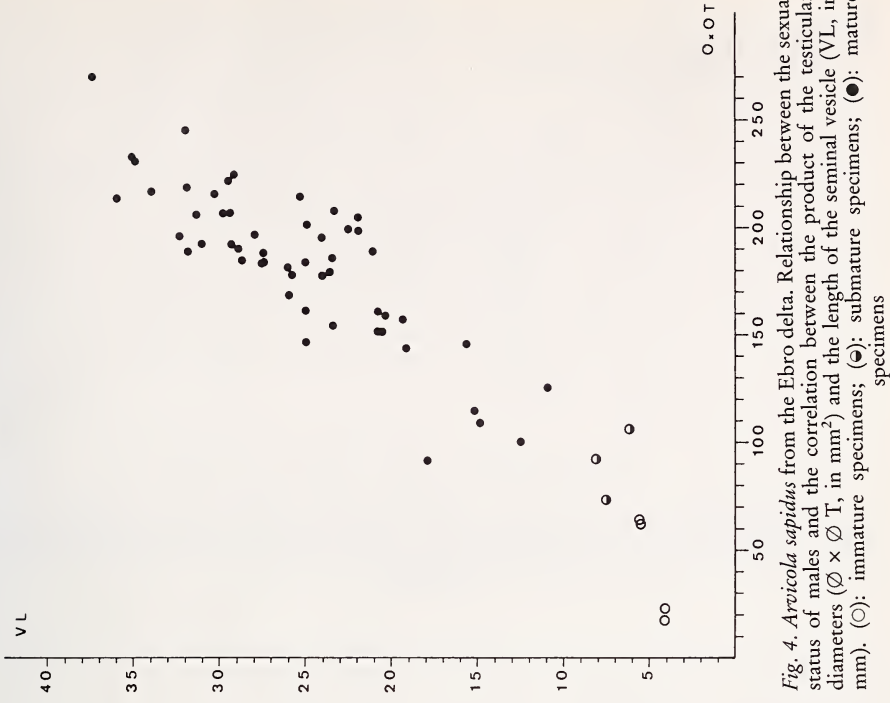


Fig. 4. *Arvicola sapidus* from the Ebro delta. Relationship between the sexual status of males and the correlation between the product of the testicular diameters ($O \times O T$, in mm^2) and the length of the seminal vesicle (VL, in mm). (○): immature specimens; (◐): submature specimens; (●): mature specimens

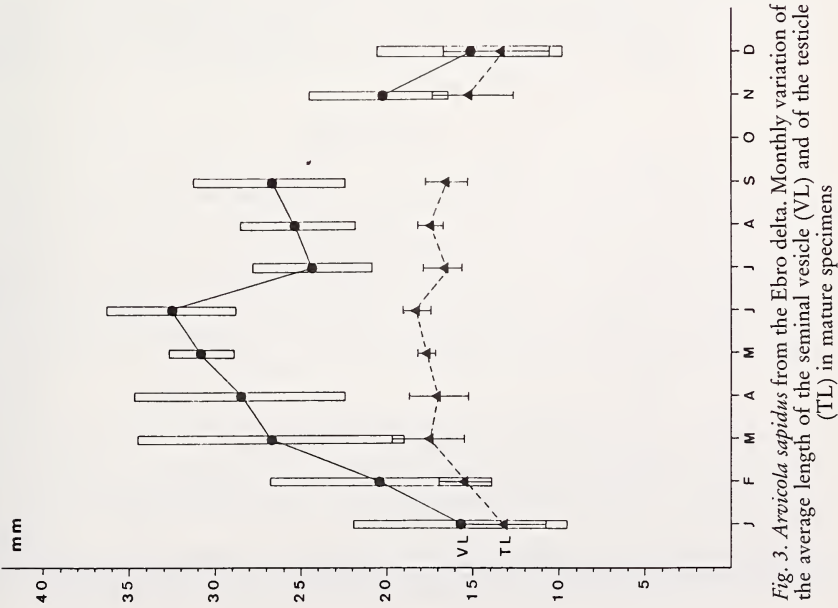


Fig. 3. *Arvicola sapidus* from the Ebro delta. Monthly variation of the average length of the seminal vesicle (VL) and of the testicle (TL) in mature specimens

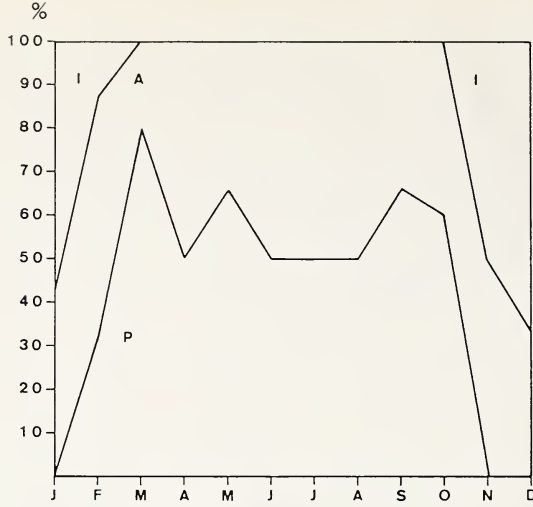


Fig. 5. *Arvicola sapidus* from the Ebro delta. Variation throughout the year of the percentage of active mature females referred to the total mature females (upper line), and percentage of pregnant females over the total of active mature females (bottom line). (I): inactive mature; (A): active mature; (P): pregnant

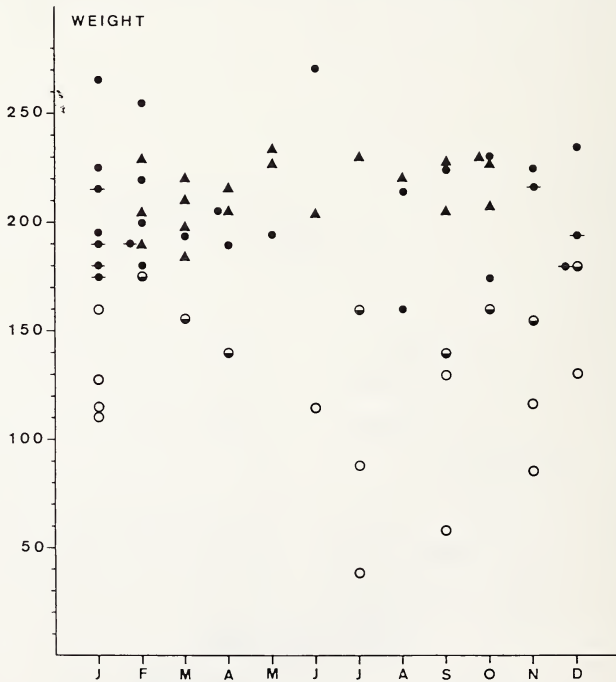


Fig. 6. *Arvicola sapidus* from the Ebro delta. Relationship between body weight (in g) and sexual status of females throughout the year. (O): immature specimens; (◐): submature specimens; (●): active mature specimens; (◑): inactive mature specimens; (▲): pregnant specimens

Pregnant females appear between February and October. However, the small sample size ($n=19$) does not allow us to discern the reproductive peaks. It can only be said in this respect that the maximum value appeared in March, in which 80% of the active mature females captured were pregnant.

All specimens weighing less than 130 g are immature (fig. 6). Between this weight and 170 g, there is a wide band of specimens that show different stages of maturity and activity but never are pregnant. All the females with body weights above 170 g can be considered sexually mature. The lightest pregnant female weighed 183 g.

It is important to note that the presence of specimens weighing less than 130 g in December and January may be evidence reproductive activity in November. Two of these specimens were captured towards the end of January (28. 1. 1982) and weighed respectively 115 and 128 g. Such individuals suggest the possibility of reproduction in December. This phenomenon is irregular and may be determined to some degree by the occurrence of relatively milder autumns.

Litter size was 2–5 embryos (see table). The average number of embryos per female was 3.31 ± 1.20 ($n=19$). No annual pattern in litter size could be determined. There seems to exist an increase of the average from February to April. Likewise no such preference of embryos would be detected. The distribution frequencies were: 0R–2L ($n=3$); 1R–1L ($n=2$); 2R–1L ($n=2$); 2R–2L ($n=2$); 3R–2L ($n=2$); 4R–1L ($n=2$); 0R–3L ($n=1$); 2R–0L ($n=1$); 2R–3L ($n=1$).

When the gestating females are grouped into three weight intervals: 180–199 g, 200–219 g and more than 219 g the following average litter sizes appear respectively: 2.0 ($n=3$); 3.87 ($n=8$); 3.25 ($n=8$). Litter size increases with body weight only in the two firsts intervals and the difference between the second and third interval is not significant.

Discussion

The literature concerning the reproductive cycle of *Arvicola sapidus* is to the date scarce and occasional. Thus, it is not possible to compare the results obtained here with those of other populations, except for those of DELOST (1968). This author mentions the presence of sexually active males throughout the whole year at the Tarn river (France). These results coincide with those observed in the Ebro delta. The decrease in size of the testicles does not seem to suppress the spermatogenic capacity. However the specimens from the summer-autumn litters take longer to acquire sexual maturity due to the decreased testicular development.

The variation in size of testicle and seminal vesicle throughout the year coincides with the seasonal variation in sexual activity reported by DELOST (1968) for males. The period of maximum activity is established by this author between April and October. The minimum values appear in December–January, and in February the activity is almost totally reestablished.

The reproductive activity of the females is maintained at maximum levels between February and October. Even though activity is less during the remaining months, this

Table
Litter size in *Arvicola sapidus* from the Ebro delta from embryo counts in pregnant females

Months	Number of embryos				
	2	3	4	5	N
February	3				3
March	2	1		1	4
April				2	2
May		1	1		2
June				1	1
July	1				1
August		1			1
September		1	1		2
October		2		1	3
Total	6	6	2	5	19

decrease never includes the whole population as approximately 35 % of the mature females continue to be active.

Pregnant females were found between February and October, during a longer period than between April and September reported by DELOST (1968). These differences may be due to environmental and climatic factors as suggested by PELIKÁN (1972) for *Arvicola terrestris*.

Even though no pregnant females appear between November and January, the constant presence of mature males throughout the year, the continued activity of some mature females during this period and the capture of juvenile individuals in December and January suggest the possibility of reproductive activity in November and December. Anyway, it is significantly lower than observed during the rest of the year.

The litter sizes found were 2–5 embryos. These values fall within the range established by DIDIER and RODE (1935) and DELOST (1968) in french populations, although the maximum values obtained by both authors (7 and 8 embryos respectively) are higher than that observed in the Ebro delta. The most frequent litters were those consisting of 2 and 3 embryos and after, those formed by 5 embryos. These results are also lower than the modal value (6 embryos) recorded by DIDIER and RODE (1935).

Even though the reproductive peaks have not been established, the high values in March agree with the observations of many authors for *Arvicola terrestris* (VAN WIJNGAARDEN 1954; PELIKÁN 1972; WIELAND 1973) that it is precisely at the beginning of the reproductive period when the sexual activity is at its highest.

At the population level, *A. sapidus* of the Ebro delta shows a general period of high sexual activity between February and October. The decrease in November–December may be conditioned by intrinsic factors of the females, because spermatozooids are present in all mature males throughout the year. Therefore despite the apparent reproductive capacity of the males, the non-receptivity of a high percentage of females determine meager chances for reproduction. Additionally to be kept into account is the size reduction of the testicles and seminal vesicles during these months. Even though the possession of spermatozooids enables the animal to be considered sexually active, the efficiency of these cells for reproduction is yet to be verified. Possibly the seminal vesicles have a direct influence on the viability of the spermatozooids, since the substances contained in the secreted liquid are important for the nutrition and protection of the reproductive cells (GUYTON 1967; HOUSSAY 1969), while also facilitating fecundation (HOGARTH 1978). Therefore even if spermatozooids are produced, an animal with an insufficient seminal vesicle may not be apt for reproduction.

Despite these factors, the existence of a certain reproductive activity in December suggests the influence of extrinsic (environmental) factors which can alter to a certain degree this activity in different years.

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Zusammenfassung

Zur Fortpflanzungsbiologie von Arvicola sapidus (Rodentia, Arvicolidae) im Ebro-Delta in Spanien

An 79 Männchen und 66 Weibchen von *Arvicola sapidus*, die in den Jahren 1981–1984 im Ebro-Delta in Spanien gefangen worden waren, wurde das Fortpflanzungsverhalten und seine Abhängigkeit von Gewicht und Jahreszeit untersucht. Dazu wurden die folgenden Parameter bewertet: Bei den Männchen das mikroskopische Bild des Hodens, sein größter und kleinster Durchmesser und die Länge der Vesicula seminalia; bei den Weibchen der Zustand der Vulva, Größe und Durchblutung der

Uteri und Ovarien, das Auftreten und die Anzahl von Embryonen und das Auftreten vom *Maculae cyaneae*.

Bei den adulten Männchen findet man ganzjährig Spermatozoen, obwohl die Größe von Hoden und Vesikeldrüsen im Jahreslauf stark schwanken. Am kleinsten sind sie von Dezember bis Januar, am größten im Juni. Von März bis Oktober sind alle geschlechtsreifen Weibchen auch geschlechtstätig. Am geringsten ist ihr Anteil im Dezember und Januar. Trächtige Weibchen kamen nur von Februar bis Oktober vor. Die durchschnittliche Embryonenzahl war 3,31. Der Nachweis von Spermien bei den Männchen und geschlechtstätigen Weibchen auch im Winter sowie von Jungtieren im Januar deutet darauf hin, daß Fortpflanzung gelegentlich auch im Winter vorkommt.

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